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Assistant Commissioner for Patents  
Washington, DC 20231  
ATTN: BOX UTILITY APPLICATION

UTILITY  
PATENT APPLICATION  
TRANSMITTAL  
Docket No.: 99-478  
Date: November 21, 2000

Sheet 1 of 2

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Inventor Name(s):  
THOMAS P. MULLER

Title:  
APPARATUS AND METHOD OF PROVIDING A WORK MACHINE

- ☒ Fee Transmittal Form Attached in Duplicate
- ☒ Specification and Claim(s) [Total Pages  ]
- ☒ Drawing(s) [Total Sheets  ]  

FORMAL

Declaration [Total Pages  ]

- ☒ Newly Executed (Original or Copy)
- ☐ Copy From Prior Application (37 CFR § 1.63(d))
  - ☐ Deletion of Inventor(s) (37 CFR § 1.63(d)(2))  
(Signed Statement Attached)
- ☒ Assignment Papers (Cover Sheet and Document(s))
- ☐ 37 CFR § 3.73(b) Statement (if applicable) ☐ Power of Attorney
- ☐ English Translation Document (if applicable)
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- ☐ Other

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If a Continuing Application

☐ Continuation      ☐ Divisional      ☐ Continuation-In-Part (CIP)

of prior Application No.: \_\_\_\_\_ ;

Examiner : \_\_\_\_\_ ; and

Group/Art Unit: \_\_\_\_\_ .

☐ Cancel Claims: \_\_\_\_\_

For Continuations or Divisional Applications only: The entire disclosure of the prior application, from which an oath or declaration is supplied, as set forth above, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference.

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Attorney/Agent: Byron G. Buck II

Registration No.: 40,537

Signature: \_\_\_\_\_

Caterpillar Inc.

Date: 11/21/00

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# FEE TRANSMITTAL for FY 2000

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Small Entity payments must be supported by a small entity statement,  
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See 37 C.F.R. §§ 1.27 and 1.28.

**TOTAL AMOUNT OF PAYMENT** (\$) 2,280

## Complete if Known

Application Number (Unassigned)  
Filing Date (Herewith)  
First Named Inventor THOMAS P. MULLER  
Examiner Name (Unassigned)  
Group / Art Unit (Unassigned)  
Attorney Docket No. 99-478

## METHOD OF PAYMENT (check one)

1. ☒ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

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- ☒ Charge Any Additional Fee Required Under 37 CFR §§ 1.16 and 1.17

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## FEE CALCULATION

### 1. BASIC FILING FEE

| Large Entity Fee Code (\$) | Small Entity Fee Code (\$) | Fee Description        | Fee Paid |
|----------------------------|----------------------------|------------------------|----------|
| 101 690                    | 201 345                    | Utility filing fee     | 710      |
| 106 310                    | 206 155                    | Design filing fee      |          |
| 107 480                    | 207 240                    | Plant filing fee       |          |
| 108 690                    | 208 345                    | Reissue filing fee     |          |
| 114 150                    | 214 75                     | Provisional filing fee |          |

**SUBTOTAL (1)** (\$) 710

### 2. EXTRA CLAIM FEES

| Total Claims       | Extra Claims | Fee from below | Fee Paid |
|--------------------|--------------|----------------|----------|
| 45                 | 25           | 18             | 450      |
| 17                 | 14           | 80             | 1,120    |
| Multiple Dependent |              |                |          |

\*\*or number previously paid, if greater; For Reissues, see below

| Large Entity Fee Code (\$) | Small Entity Fee Code (\$) | Fee Description  |
|----------------------------|----------------------------|--|
| 103 18                     | 203 9                      | Claims in excess of 20                                     |
| 102 78                     | 202 39                     | Independent claims in excess of 3                          |
| 104 260                    | 204 130                    | Multiple dependent claim, if not paid                      |
| 109 78                     | 209 39                     | ** Reissue independent claims over original patent         |
| 110 18                     | 210 9                      | ** Reissue claims in excess of 20 and over original patent |

**SUBTOTAL (2)** (\$) 1,570

## FEE CALCULATION (continued)

### 3. ADDITIONAL FEES

| Large Entity Fee Code (\$) | Small Entity Fee Code (\$) | Fee Description  | Fee Paid |
|----------------------------|----------------------------|--|----------|
| 105 130                    | 205 65                     | Surcharge - late filing fee or oath  |          |
| 127 50                     | 227 25                     | Surcharge - late provisional filing fee or cover sheet.                    |          |
| 139 130                    | 139 130                    | Non-English specification  |          |
| 147 2,520                  | 147 2,520                  | For filing a request for reexamination                                     |          |
| 112 920*                   | 112 920*                   | Requesting publication of SIR prior to Examiner action                     |          |
| 113 1,840*                 | 113 1,840*                 | Requesting publication of SIR after Examiner action                        |          |
| 115 110                    | 215 55                     | Extension for reply within first month                                     |          |
| 116 380                    | 216 190                    | Extension for reply within second month                                    |          |
| 117 870                    | 217 435                    | Extension for reply within third month                                     |          |
| 118 1,360                  | 218 680                    | Extension for reply within fourth month                                    |          |
| 128 1,850                  | 228 925                    | Extension for reply within fifth month                                     |          |
| 119 300                    | 219 150                    | Notice of Appeal   |          |
| 120 300                    | 220 150                    | Filing a brief in support of an appeal                                     |          |
| 121 260                    | 221 130                    | Request for oral hearing   |          |
| 138 1,510                  | 138 1,510                  | Petition to institute a public use proceeding                              |          |
| 140 110                    | 240 55                     | Petition to revive - unavoidable   |          |
| 141 1,210                  | 241 605                    | Petition to revive - unintentional   |          |
| 142 1,210                  | 242 605                    | Utility issue fee (or reissue)   |          |
| 143 430                    | 243 215                    | Design issue fee   |          |
| 144 580                    | 244 290                    | Plant issue fee  |          |
| 122 130                    | 122 130                    | Petitions to the Commissioner  |          |
| 123 50                     | 123 50                     | Petitions related to provisional applications                              |          |
| 126 240                    | 126 240                    | Submission of Information Disclosure Stmt                                  |          |
| 581 40                     | 581 40                     | Recording each patent assignment per property (times number of properties) |          |
| 146 690                    | 246 345                    | Filing a submission after final rejection (37 CFR § 1.129(a))              |          |
| 149 690                    | 249 345                    | For each additional invention to be examined (37 CFR § 1.129(b))           |          |
| Other fee (specify)        |                            |  |          |
| Other fee (specify)        |                            |  |          |

\* Reduced by Basic Filing Fee Paid

**SUBTOTAL (3)** (\$) 0

## SUBMITTED BY

Name (Print/Type) Byron G. Buck II

Registration No. (Attorney/Agent) 40,537

Complete (if applicable)

Telephone (309) 675-6717

Signature

Date 11/21/2000

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Description

APPARATUS AND METHOD OF PROVIDING A WORK MACHINE

5 This application claims the benefit of prior  
provisional patent application Serial No. 60/210,058.

Technical Field

10 This invention relates generally to an  
apparatus and method of providing at least one work  
machine and, more particularly, to determining the  
productivity of a work machine.

Background Art

15 Work machines having an attached implement,  
such as motorgraders, excavators, mining shovels,  
backhoe loaders, track-type tractors, wheeled  
tractors, compactors, wheel loaders, and the like, are  
used for moving earth. Such implements may include  
20 blades, impact rock rippers, buckets, and other  
material handling apparatus. Typically, work machines  
may be configured to perform various work cycles. For  
example, a wheel loader typically has a bucket used to  
rack, lift, dump, and lower a load and may be used to  
25 carry a load from one point to another point. These  
capabilities of a wheel loader are typically combined  
to perform a work cycle such as a hard bank loading,  
load and carry, truck loading cycle and the like.

In general, a work machine has a certain  
30 productivity, in terms of tons of material handled per

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gallon of fuel consumed. Productivity of the work machine is of imperative importance to the customer because it is generally directly related to the income and/or revenues received by the customer. Therefore, customers desire a work machine provider to execute a guaranteed productivity customer support agreement (CSA). These CSAs contractually guarantee a predetermined productivity of the work machine to the customer, thereby effectively shifting the risk of nonperformance (breakdown) to another party like the work machine provider or manufacturer.

Ideally, work machine providers, whether they be manufacturers, dealers, rental fleet operators or the like, could monitor the work machine and determine when maintenance and service of the work machine was necessary prior to a significant deterioration of productivity, or even worse a breakdown of the work machine, thereby enabling providers to execute a CSA. However, to date, work machine providers have had difficulty accurately and consistently determining the need for maintenance and service of a work machine before productivity significantly deteriorates. Customer support agreements typically available today are generally based on a level of machine maintenance or machine availability.

Accordingly, the art has sought an apparatus and method of determining the productivity of a work machine which: senses the work performed by the machine; calculates the productivity of the machine;

selects a guaranteed productivity customer support agreement in response to the productivity; may be used in a timely and efficient manner; and is more economical to manufacture and use.

5           It is known from United States Patent number  
5,065,349 to Thomas of November 12, 1991, to measure  
the performance of an individual who rents a vehicle  
or other complex machine to be sure the machine is not  
abused during such rental use. Further, it is known  
10 from United States Patent number 5,631,832 to  
Hagenbuch of May 20, 1997, to process data derived  
from the weight of a load carried by a hauling  
vehicle, detect the change in the weight of the load,  
formulate data indicative of hauling conditions of the  
15 vehicle, and accumulate historical data for  
formulating management decisions directed to the  
future operation of the vehicle. Additionally, it is  
known from United States Patent number 5,808,907 to  
Shetty et al. of September 15, 1998, to provide  
20 information relating to a machine to a user by sensing  
predetermined events relating to the machine,  
producing corresponding event signals, delivering the  
event signals to a remote site, comparing the event  
signals to a profile of events corresponding to the  
25 user and delivering a notification signal to the user  
if the event signals match a profile.

However, it is currently difficult for a work machine provider to accurately and consistently predict when a work machine needs service and maintenance prior to productivity significantly

deteriorating so that the provider can economically execute a guaranteed productivity customer support agreement with a customer.

The present invention is directed to  
5 overcoming one or more of the problems as set forth above.

#### Disclosure of the Invention

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10 In an embodiment of the present invention a system for determining a guaranteed productivity support agreement for a customer is provided. The system includes at least one machine sensor and at least one computer. The at least one machine sensor is adapted to provide at least one machine sensor  
15 signal indicative of the work performed by the machine. The computer is adapted to receive the sensor signal, calculate the productivity of the machine and select a guaranteed productivity customer support agreement in response to the productivity.

20 In an embodiment of the present invention a method for determining a guaranteed customer support agreement for customer is provided. The method includes the steps of determining the productivity of the machine and generating a guaranteed productivity  
25 customer support agreement establishing at least one minimum productivity limit.

In an embodiment of the present invention a system for measuring operator productivity of at least one work machine for customer is provided. The system  
30 includes at least one machine sensor and a computer.

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The machine sensor is adapted to provide at least one machine sensor signal indicative of the operation performed by the machine, the payload handled by the machine and the amount of fuel consumed by the machine. The computer includes a central processing unit and is adapted to receive the sensor signals and calculate the productivity of the machine, the productivity being a function of an amount of fuel consumed and at least one of a payload handled by the machine and an operation performed by the machine.

In an embodiment of the present invention a method of providing incentives to an operator of a work machine is provided. The method includes the steps of determining a work cycle performed by the machine, determining the productivity of the machine, comparing the productivity of the machine with normalized operator productivity data for the work cycle, determining a skill level of the operator in response to comparing the productivity of the machine with the productivity data, determining the change in skill level of the operator in response to comparing the productivity of the machine with the productivity data and providing an incentive to the operator for at least achieving a predetermined change in skill level.

In an embodiment of the present invention a system for determining when a work machine needs service is provided. The system includes at least one machine sensor and a computer. The at least one machine sensor is adapted to provide at least one machine sensor signal indicative of the operation



performed by the machine, the payload handled by the machine and the amount of fuel consumed by the machine. The computer is adapted to receive the sensor signals, calculate the productivity of the machine, determine the skill level of the operator, calculate the change in productivity of the machine and skill level of the operator, determine whether the productivity of the machine is deteriorating and provide a service notice signal in response to determining whether the productivity of the machine is deteriorating.

In an embodiment of the present invention, a work machine adapted to be controlled by an operator and for acting upon a load through a plurality of work cycles is provided. The work machine includes a frame, plurality of ground engaging devices, an operator compartment, an implement, an engine and a system. The plurality of ground engaging devices support the frame. The operator compartment is supported by the ground engaging devices. The implement has a linkage for operably connecting the implement to the frame. The engine is operably coupled to the ground engaging devices. The system includes at least one machine sensor and a computer. The at least one machine sensor is adapted to provide at least one machine sensor signal indicative of the operation performed by the machine, the payload handled by the machine and the amount of fuel consumed by the machine. The computer is adapted to receive the sensor signals, calculate the productivity of the

machine and determine a skill level of an operator of the machine.

In an embodiment of the present invention a system for determining fees to be paid by a customer that are based on machine productivity is provided. The system includes at least one machine sensor and a computer. The at least one machine sensor is adapted to provide at least one machine sensor signal indicative of the operation performed by the machine, the payload handled by the machine, and the amount of fuel consumed by the machine. The computer is adapted to received the sensor signals, calculate the productivity of the machine and determine a skill level of the operator of the machine.

#### Brief Description of the Drawings

For a better understanding of the invention, reference may be made to the accompanying drawings in which:

Fig. 1 is a side view of a work machine of a preferred embodiment of the present invention;

Fig. 2 is a graph of normalized operator productivity data for an embodiment of the present invention;

Fig. 3 is a graph of productivity versus fuel consumed for several work cycles for an embodiment of the present invention;

Fig. 4 is a flow chart of software logic implemented in an embodiment of the present invention.

Best Mode for Carrying Out the Invention

5 A preferred embodiment of the present invention provides an apparatus and method of providing at least one work machine to a customer. The following description uses a wheel loader as an example only. This invention can be applied to other types of work machines and other types of implements as is well known in the art. Other examples include, 10 mining shovels, motorgraders, backhoe loaders, track-type tractors, wheeled tractors, compactors, track-type rotors, and the like.

15 In Fig. 1, a work machine 100 having a frame 105, plurality of ground engaging devices 110, an operator compartment 115 an implement 120, an engine 125 and a system 130.

20 The plurality of ground engaging devices 110 support the frame 105 and the operator compartment 115. The implement 120 may have a linkage 135 for operably connecting the implement 120 to the frame 105. The engine 125 is operably coupled to the ground engaging devices 110.

25 The system 130 includes at least one machine sensor (not shown), a computer 140, preferably associated with at least one data storage device 145, and preferably includes a communication device 150.

30 The machine sensor is adapted to provide machine sensor signals indicative of the work performed by the work machine 100. Preferably, the

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machine sensors include at least one operation sensor adapted to provide operating sensor signals indicative of the operation performed by the machine, at least one payload sensor adapted to provide payload sensor signals indicative of the payload handled by the machine and at least one fuel sensor adapted to provide fuel consumption sensor signals indicative of the amount of fuel consumed by the machine. The operation sensor may be any or a combination of pressure sensors or transducers, flow sensors or transducers, radial or axial sensors, transducers or potentiometers, sonic, microwave, laser, waveguide or other device or system for determining the angles of displacement about a pivot joint or relationship of the implement 120 to the rest of the work machine 100 or for determining the movement of the ground engaging devices 110 with respect to the rest of the work machine 100. Similarly, the payload sensor could be any or a combination of pressure sensors or transducers, flow sensors or transducers, radial or axial sensors, transducers or potentiometers and other sonic, microwave, laser, waveguide or other device or system for indicating the weight of the payload handled by the work machine 100.

As should be appreciated, the at least one fuel sensor may be any or a combination of a fuel tank fuel level sensor; a fuel or lubricating or hydraulic fluid line pressure or flow sensor or transducer; a device for measuring, controlling and/or accumulating fuel injection to a combustion chamber of engine 125;

a suction gas monitoring system; an exhaust gas monitoring system; and the like.

5 The at least one data storage device 145 may be any of a number of data storage devices adapted to store information on a storage medium such as random access memory, read-only memory, electrically erasable programmable read-only memory, traditional hard drives, optical discs and the like. Preferably, the data storage device 145 stores information including  
10 empirical data, values representing a message record, values representing the sensor signals, normalized operator productivity data for at least one work cycle, normalized expected improvement in skill level data for at least one work cycle and guaranteed  
15 productivity customer support agreements.

The computer 140 is adapted to receive these sensor signals and calculate the productivity of the machine 100. The computer 140 preferably includes a central processing unit for receiving the sensor  
20 signals and calculating the productivity of the machine 100. Preferably, computer 140 is one of many readily available computers capable of processing numerous instructions. It should be appreciated that computer 140 may include multiple processing units  
25 configured in a distributed structure environment and forming a system. Such distributed processors may be continuously or intermittently connected through any of numerous communications devices including such devices as direct hardwired data links, radio and

other transmission devices, optical transmission devices and the like.

Preferably, the productivity is a function of the amount of fuel consumed and at least one of the payload handled by the machine and the operation performed by the machine. However, it should be appreciated that the productivity could be determined by other methods of calculating or approximating the work performed by the machine 100 within a time period.

In one or more embodiments of the present invention it may be advantageous for the computer 140 to be adapted to perform one or more of the tasks explained below.

Advantageously, the computer 140 compares the sensor signals to empirical data and determines a work cycle performed by the machine 100. It is appreciated that the specific values of the empirical data depend upon the specific model and in many cases configuration of the work machine 100. However, such data can be readily and easily determined through experimentation by monitoring the movements of the machine and the operating characteristics of the control systems, including flows, pressures and the like such that particular characteristics of the machine 100 can be identified and associated various work cycles.

Advantageously, computer 140 may provide a productivity notice signal indicative of the productivity of the machine 100.

Preferably, the computer 140 determines the skill level of the operator and may additionally provide a skill level notice signal. The skill level of the operator is preferably determined by comparing the productivity of the machine 100 with the normalized operator productivity data for the work cycle. Such a distribution curve 200 indicating the relative skill levels of an operator is shown in Fig. 2. Advantageously the skill levels are novice 205, average 210 and expert 215. It should be appreciated that the specific normalized operator productivity data for the work cycle may vary with model and configuration of work machine 100. The distribution curve 200 is shown by a curve of productivity in terms of tons per gallon per hour, tons per gallon per mile, or the like for various work cycles. It should be appreciated that any number of skill level classifications could be readily and easily used without deviating from scope of the present invention as defined in the appending claims.

Preferably, the computer 140 selects and/or generates a CSA. Advantageously, the CSA establishes at least one minimum productivity limit and a corresponding price in response to the productivity of the machine or alternatively the skill level. It is advantageous for the computer 140 to select a particular CSA from a plurality of CSAs based upon the productivity of the machine 100 during a trial or initial period of use.

A CSA could be any of a number of documents containing terms of sale, rental, lease, and the like and includes terms guaranteeing the level of productivity of machine 100. Computer 140 preferably  
5 selects a CSA with a minimum productivity limit substantially corresponding to the productivity of the machine 100 during the trial period. The productivity limit may vary during the term of the CSA with the experience of the operator.

10 Preferably the computer 140 continues to monitor the machine 100 and continuously calculates the productivity of the machine 100 and determines the skill level of the operator. Additionally, it is advantageous for the computer 140 to calculate the  
15 change in productivity of the machine and skill level of the operator over a predefined time period. It should be appreciated that numerous different time periods could be readily and easily used without deviating from the scope of the present invention as  
20 defined in the appended claims. For example, many different time periods could be used depending upon the resolution desired. Preferably, this could be calculated on a daily basis.

Advantageously, the data storage device is  
25 adapted to store the change in productivity of the machine and skill level of the operator. This historical data may be provided to the computer and/or operator, service organization, customer or owner of the machine 100.



Preferably, computer 140 determines whether the productivity is deteriorating. Advantageously, the computer 140 compares the change in productivity of the machine 100 with the normalized expected improvement in skill level data to determine whether the productivity is deteriorating.

For example, in Fig.3 load and carry data curve 300, hard bank data curve 305 and clean up data curve 310 all are representative curves indicating an expected relationship between the tons of payload handled, vertical axis 330, and the fuel consumed by a machine 100, horizontal axis 335. As the skill level of the operator increases with experience the tons of payload handled by the machine 100 increases with the fuel consumed. Truck loading data curve 315 is representative of a relationship between the tons of payload handled and the fuel consumed by machine 100 and indicates a potential problem. Productivity of machine 100 generally corresponding to these data curves may advantageously be compared with the normalized expected improvement in skill level data to determine if the productivity has changed as the skill level of the operator is generally expected to increase as a result of additional experience. If the skill level of the operator is expected to increase as shown in Fig. 2, then computer 140 would determine that there was a deterioration in productivity of the machine 100 if the change in productivity of machine 100 changes from initial productivity 320 to subsequent productivity 325 during a truck loading

work cycle. It should be understood that tolerances of a reasonable amount may be employed in the comparisons. The actual tolerance employed is dependent, at least partially, on the resolution  
5 desired and can be readily and easily determined through numerical analysis or experimentation for the particular model and configuration of the machine 100.

If computer 140 determines there was a deterioration in productivity of the machine 100, then  
10 it is advantageous for the computer 140 to provide one or more notice signals indicating any of a variety of levels of deterioration in productivity. Such notice signals may include a productivity deterioration warning notice signal, a service notice signal, a CSA  
15 warning notice signal and the like. A productivity deterioration warning notice signal would preferably provide an early warning and indicate that the productivity is beginning to deteriorate. A service notice signal would preferably indicate that the  
20 productivity has deteriorated and that maintenance should be performed. A CSA warning notice signal would preferably provide a warning and indicate that the productivity is deteriorating and is falling or will likely fall below the minimum productivity limit  
25 guaranteed in the CSA.

Preferably, computer 140 generates at least one message record. The message record advantageously includes at least one of the sensor signals and notice signals.

Referring back to Fig. 1, communication device 150 is preferably adapted to receive the message record and provide the message record to at least one of the operator, a service organization, the customer and an owner of the machine. The communication device 150 is generally a device capable of transferring the message record and may include such devices as data transmission wires, modems, radios and other signal transmission devices, optical transmission devices, wave guides, microwave communication devices, satellite communication devices and the like. Communication device 150 advantageously includes a user interface system that may be any or a combination of interface devices readily available such as radio reception and generation devices, scanners, modems, printers, fax machines, bar code readers, touch screens, and preferably a video display or graphic display in combination with a keyboard. Additionally, it may be advantageous for the interface system to include a printer adapted to provide a document indicating the signals included in the message record and to provide a document indicating and/or including the CSA.

Referring now to Fig. 4, a flowchart of the software logic used in connection with the preferred embodiment is shown. Those skilled in the art could readily and easily write software implementing the flowchart shown in Fig. 4 using the instruction set, or other appropriate language associated with the particular microprocessor to be used. First block 400

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seventh block 414 program control passes to second block 402.

In sixth block 412, the computer 140 calculates the change in productivity and skill level.

5 From sixth block 412 program control passes to second decision block 416.

In second decision block 416, the computer 140 determines whether the productivity is deteriorating. If the productivity is not  
10 deteriorating, program control passes back to second block 402. Otherwise, program control passes to eighth block 418.

In eighth block 418, the computer 140 provides productivity deterioration warning service  
15 and agreement warning notice signals. From eighth block 418, program control returns to the main program.

The logic of Fig. 4 is performed frequently enough to provide the desired resolution and time  
20 responsiveness for determining and alerting at least one of an operator, a service organization, the customer and an owner of the work machine 100 of a deterioration in productivity and preferably performed daily.

25 While aspects of the present invention have been particularly shown and described with reference to the preferred embodiment above, it will be understood by those skilled in the art that various additional embodiments may be contemplated without  
30 departing from the spirit and scope of the present

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invention. For example, any of a number of different methods for determining the work or productivity of a work machine 100 could be readily and easily used to determine a CSA. Additionally, the expected  
5 improvement in skill level data and relative skill levels may vary in any of many possible patterns and may not be normalized. However, a device or method incorporating such an embodiment should be understood to fall within scope of the present invention as  
10 determined based on the claims below and any equivalence thereof.

#### Industrial Applicability

Work machines 100 having an attached  
15 implement 120, such as motor graders, excavators, mining shovels, backhoe loaders, wheel loaders, track-type tractors, wheeled tractors, compactors, motor graders, and the like, are used for handling a payload, for example, moving earth. Typically, work  
20 machines may be configured to perform various work cycles such as load and carry, truck loading, hard bank, clean up and the like.

Today, most customer support agreements are based on a level of machine maintenance or machine  
25 availability. With the introduction of more intelligent machines 100 it is possible to measure the productivity during various work cycles and determine a CSA that guarantees certain productivity numbers.

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These more intelligent machines 100 have many sensors and computers 140 that are used for information and control. This gives the machines 100 an ability to generate, track and store more  
5 information. Additionally, the inclusion of these devices in a machine 100 makes the machine 100 easier to operate and more productive. This is at least partially a result of automated aspects of various work cycles.

10 In general, sensors can be used to determine what the machine 100 is doing or the work cycle it is performing. The sensors can also determine the amount of payload that the machine 100 is handling. In the case of a wheel loader having a bucket as the  
15 implement 120, sensors can measure the amount of material in the bucket, the amount of fuel consumed to complete the task and the performance of the operator as compared against a predetermined performance level.

For example, it is known that an expert  
20 operator, in a truck loading operation, can load the bucket, back up turning, and go forward to dump the payload from the bucket into a truck and the tires only make three quarter ( $3/4$ ) of a revolution. The sensors can monitor the number of tire revolutions  
25 performed by the operator performing the truck loading work cycle. The computer 140 is able to time the work cycle. Less skilled operators require many more revolutions and therefore, more time (e.g.  
inexperienced operators may perform the same work  
30 cycle using as many as two and one-half ( $2 \frac{1}{2}$ ) tire

revolutions and significantly more time). This information and productivity can be stored in a data storage device 145 along with average performance data for many work cycles.

5           In at least one embodiment of the present invention it is advantageous to provide an incentive to the operator for at least achieving a predetermined change in skill level. Such a predetermined change in skill level can be determined by considering the  
10 normalized expected improvement in skill level data. Advantageously, the incentive is at least one of a reward, penalty, compensation and a failure to impose at least one of the reward, penalty and compensation and preferably includes a bonus provided to the  
15 operator.

          It is advantageous for the machine 100 to include a communications device 150 such as a wireless transmitter for transmitting information and productivity data to a distributed database where data  
20 for numerous machines 100 can be stored. Preferably this information is transmitted at the end of each shift or day if multiple shifts are used.

          Additionally, the change in skill level of the operator may be monitored and stored. The  
25 relative skill level of an operator may be determined and stored for any given work cycle performed during a trial period near the time the machine is provided. As the operator gains experience, his/her skill level should increase and move up along the normalized  
30 operator productivity curve. The expected progress of

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the operator in this manner gives rise to the normalized expected improvement in skill level data.

In an embodiment of the present invention the machine 100 can be provided to a customer where it would be used for a period of time. At the end of the period, all of the information can be transmitted to a distributed computer 140 and analyzed. Based on this analysis a CSA can be selected or generated and provided. The productivity of the machine 100 can continue to be monitored. If the computer 140 determines that the productivity is deteriorating, then a message record can be provided to the party guaranteeing the productivity of the machine 100 so that maintenance can be planned or conveniently scheduled.

The apparatus and method of certain embodiments of the present invention, when compared with other methods and apparatus, may have the advantages of sensing the work performed by the machine 100; calculating the productivity of the machine 100; selecting a CSA in response to the productivity; being used in a timely and efficient manner; and being more economical to manufacture and use. Such advantages are particularly worthy of incorporating into the design, manufacture, and operation of work machines 100. In addition, the present invention may provide other advantages that have not been discovered yet.

It should be understood that while the preferred embodiment as described in connection with a



Claims

1. A system for determining a guaranteed  
productivity support agreement for a customer,  
5 comprising:

at least one machine sensor adapted to  
provide at least one machine sensor signal indicative  
of the work performed by the machine;

10 at least one computer adapted to  
receive the sensor signal,  
calculate the productivity of the  
machine, and  
select a guaranteed productivity  
customer support agreement in response to the  
15 productivity.

2. The system of claim 1, wherein the  
computer is adapted to determine whether the  
productivity of the machine is deteriorating and  
20 provide a productivity deterioration warning notice  
signal in response to determining the productivity of  
the machine is deteriorating.

3. A system for providing at least one  
25 work machine to a customer, comprising:

at least one machine sensor adapted to  
provide at least one machine sensor signal indicative  
of the operation performed by the machine, the payload  
handled by the machine and the amount of fuel consumed  
30 by the machine; and



5  
10

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at least one data storage device adapted to store on a storage medium information including empirical data, values representing the sensor signals, normalized operator productivity data for at

least one work cycle, normalized expected improvement  
in skill level data for at least one work cycle and at  
least one guaranteed productivity customer support  
agreement having at least one minimum productivity

5 limit and corresponding price;

a computer including a CPU adapted to

receive the sensor signals,

compare the sensor signals to the

empirical data to determine a work cycle

10 performed by the machine,

calculate the productivity of the

machine and provide a productivity notice signal,

the productivity being a function of an amount of  
fuel consumed and at least one of a payload

15 handled by the machine and an operation performed  
by the machine,

determine a skill level of the operator

and provide a skill level notice signal, the

skill level of the operator being determined by

20 comparing the productivity of the machine with  
the normalized operator productivity data for the  
work cycle,

select and generate the guaranteed

productivity customer support agreement

25 establishing at least one minimum productivity  
limit and corresponding price in response to the  
skill level,

monitor the machine,

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continuously calculate the productivity of the machine and determine the skill level of the operator,

5 calculate the change in the productivity of the machine and skill level of the operator, the data storage device being adapted to store the change in the productivity of the machine and skill level of the operator,

10 determine whether the productivity of the machine is deteriorating as a function of at least one of the change in the productivity of the machine, the change in the skill level of the operator and the normalized expected improvement in skill level data,

15 provide a productivity deterioration warning notice signal in response to determining the productivity of the machine is deteriorating,

20 provide a service notice signal in response to the step of determining whether the productivity of the machine is deteriorating,

provide an agreement warning notice signal in response to the step of determining whether the productivity of the machine is deteriorating and considering the limit,

25 generate at least one message record, the message record including at least one of the signals and notice signals, and

30 the data storage device being adapted to store values representing the message record; and

at least one communication device adapted to receive the message record and provide the message record to at least one of the operator, a service organization, the customer and an owner of the machine.

7. A method of determining a guaranteed customer support agreement for a customer, the method comprising the steps of:

10 determining the productivity of the machine; and

generating a guaranteed productivity customer support agreement establishing at least one minimum productivity limit.

8. The method of claim 7, wherein an operator operates the machine and including the step of determining a skill level of the operator.

9. The method of claim 8, including the steps of determining whether the productivity of the machine is deteriorating and communicating a productivity deterioration warning notice to at least one of the operator, a service organization, the customer and an owner of the machine.

10. A method of providing at least one work machine to a customer, the method comprising the steps of:



determining the productivity of the machine,  
the productivity being at least a function of a time  
period, a fuel consumed and at least one of a payload  
handled by the machine and an operation performed by  
5 the machine;

determining a skill level of the operator;  
generating a guaranteed productivity  
customer support agreement establishing at least one  
minimum productivity limit and corresponding price in  
10 response to the skill level;

determining whether the productivity of the  
machine is deteriorating; and

communicating a productivity deterioration  
warning notice to at least one of the operator, a  
15 service organization, the customer and an owner of the  
machine.

11. The method of claim 10, including the  
steps of monitoring the operation of the machine and  
20 determining a work cycle performed by the machine.

12. The method of claim 11, wherein the  
machine is operated by an operator and including the  
steps of comparing the productivity of the machine  
25 with normalized operator productivity data for the  
work cycle and determining a skill level of the  
operator in response to the step of comparing the  
productivity of the machine with the productivity  
data.

13. The method of claim 12, including the steps of performing comparisons of the productivity of the machine with the productivity data and determining the change in the skill level of the operator in response to the step of performing subsequent comparisons of the productivity of the machine with the productivity data.

14. The method of claim 13, including the step of providing an incentive to the operator for at least achieving a predetermined change in skill level, such predetermined change in skill level being determined by considering a normalized expected improvement in skill level, and the incentive being at least one of a reward, penalty, compensation, and failure to impose at least one of a reward, penalty and compensation.

15. The method of claim 13, including the steps of determining a productivity deterioration warning notice in response to performing subsequent comparisons of the productivity of the machine with the productivity data and considering the normalized expected improvement in skill level, determining a service notice in response to the step of determining whether the productivity of the machine is deteriorating and determining an agreement warning in response to the step of determining whether the productivity of the machine is deteriorating and considering the limit.



performing subsequent comparisons of the  
5 productivity of the machine with the productivity  
data;

providing an incentive to the operator for at least achieving a predetermined change in skill level, such predetermined change in skill level being determined by considering a normalized expected improvement in skill level, and the incentive being at least one of a reward, penalty, compensation, and failure to impose at least one of a reward, penalty and compensation;

determining a service notice in response to the step of determining whether the productivity of the machine is deteriorating;

determining an agreement warning in response  
30 to the step of determining whether the productivity of

the machine is deteriorating and considering the limit;

generating at least one message record;

including in the message record a signal

5 indicative of at least one of the productivity, skill level, service notice, agreement warning, productivity deterioration warning notice, time period, fuel consumed, payload handled by the machine and the operation performed by the work machine; and

10 communicating the message record to at least one of the operator, a service organization, the customer and an owner of the machine.

18. A work machine adapted to be controlled  
15 by an operator and for acting upon a load through a plurality of work cycles, comprising:

a frame;

a plurality of ground engaging devices supporting the frame;

20 an operator compartment supported by the ground engaging devices;

an implement having a linkage for operably connecting the implement to the frame;

25 an engine operably coupled to the ground engaging devices; and

a system for determining a guaranteed productivity support agreement for a customer, including:

at least one machine sensor adapted to provide at least one machine sensor signal indicative of the work performed by the machine;

at least one computer adapted to  
5 receive the sensor signal,  
calculate the productivity of the  
machine, and  
select a guaranteed productivity  
customer support agreement in response to the  
10 productivity.

19. The work machine of claim 18, wherein the computer is adapted to determine whether the productivity of the machine is deteriorating and provide a productivity deterioration warning notice signal in response to determining the productivity of the machine is deteriorating.

20. A work machine adapted to be controlled  
20 by an operator and for acting upon a load through a  
plurality of work cycles, comprising:

a frame;  
 a plurality of ground engaging devices  
 supporting the frame;  
 25 an operator compartment supported by the  
 ground engaging devices;  
 an implement having a linkage for operably  
 connecting the implement to the frame;  
 an engine operably coupled to the ground  
 30 engaging devices; and

a system for measuring operator productivity  
of at least one work machine for a customer,  
including:

5           at least one machine sensor adapted to  
provide at least one machine sensor signal  
indicative of the operation performed by the  
machine, the payload handled by the machine and  
the amount of fuel consumed by the machine;

10           at least one data storage device  
adapted to store information on a storage medium;

          a computer adapted to  
          receive the sensor signals,  
          calculate the productivity of the  
machine, the productivity being a function  
15           of an amount of fuel consumed and at least  
one of a payload handled by the machine and  
an operation performed by the machine,

          calculate the change in the  
productivity of the machine, the data  
20           storage device being adapted to store the  
change in the productivity of the machine;  
and

          determine whether the productivity of  
the machine is deteriorating.

25

21. A system for measuring operator  
productivity of at least one work machine for a  
customer, comprising:

30           at least one machine sensor adapted to  
provide at least one machine sensor signal indicative

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of the operation performed by the machine, the payload handled by the machine and the amount of fuel consumed by the machine; and

5                   a computer including a CPU adapted to  
                  receive the sensor signals and  
                  calculate the productivity of the  
                  machine, the productivity being a function of an  
                  amount of fuel consumed and at least one of a  
                  payload handled by the machine and an operation  
10                  performed by the machine.

22. The system of claim 21, wherein the  
computer is adapted to calculate the change in the  
productivity of the machine.

15                  23. A system for measuring operator  
                  productivity of at least one work machine for a  
                  customer, comprising:

                  at least one machine sensor adapted to  
20                  provide at least one machine sensor signal indicative  
                  of the operation performed by the machine, the payload  
                  handled by the machine and the amount of fuel consumed  
                  by the machine;

                  at least one data storage device adapted to  
25                  store information on a storage medium;

                  a computer adapted to  
                  receive the sensor signals,  
                  calculate the productivity of the  
                  machine, the productivity being a function of an  
30                  amount of fuel consumed and at least one of a



payload handled by the machine and an operation performed by the machine,

calculate the change in the productivity of the machine, the data storage device being adapted to store the change in the productivity of the machine; and

determine whether the productivity of the machine is deteriorating.

24. The system of claim 23, wherein the machine sensor includes at least one operation sensor adapted to provide at least one operating sensor signal indicative of the operation performed by the machine, at least one payload sensor adapted to provide at least one payload sensor signal indicative of the payload handled by the machine and at least one fuel sensor adapted to provide at least one fuel consumption sensor signal indicative of the amount of fuel consumed by the machine.

25. The system of claim 24, wherein the information includes empirical data, values representing the sensor signals, normalized operator productivity data for at least one work cycle and the computer is adapted to compare the sensor signals to the empirical data to determine a work cycle performed by the machine, determine a skill level of the operator and provide a skill level notice signal, the skill level of the operator being determined by comparing the productivity of the machine with the

normalized operator productivity data for the work  
cycle, calculate the change in the skill level of the  
operator and determine whether the productivity of the  
machine is deteriorating as a function of at least one  
5 of the change in the productivity of the machine, the  
change in the skill level of the operator and the  
normalized expected improvement in skill level.

26. The system of claim 25, wherein the  
10 computer is adapted to provide a productivity  
deterioration warning notice signal in response to  
determining the productivity of the machine is  
deteriorating and generate at least one message record  
including the notice signal, the data storage device  
15 is adapted to store values representing the message  
record and at least one communication device is  
adapted to receive the message record and provide the  
message record to at least one of the operator, a  
service organization, the customer and an owner of the  
20 machine.

27. A method of providing incentives to an  
operator of a work machine, the method comprising the  
steps of:  
25 determining a work cycle performed by the  
machine;  
determining the productivity of the machine;  
comparing the productivity of the machine  
with normalized operator productivity data for the  
30 work cycle;

determining a skill level of the operator in response to the step of comparing the productivity of the machine with the productivity data;

determining the change in the skill level of the operator in response to comparing the productivity of the machine with the productivity data; and

providing an incentive to the operator for at least achieving a predetermined change in skill level.

10

28. The method of claim 27, including the steps of generating at least one message record including a signal indicative of the skill level and communicating the message record to at least one of the operator, a service organization, a customer and an owner of the machine

15

29. A method of providing incentives to an operator of a work machine, the method comprising the steps of:

20

determining a work cycle performed by the machine;

25

determining the productivity of the machine, the productivity being at least a function of a time period, a fuel consumed and at least one of a payload handled by the machine and an operation performed by the machine;

30

comparing the productivity of the machine with normalized operator productivity data for the work cycle;

determining a skill level of the operator in response to the step of comparing the productivity of the machine with the productivity data;

5 determining the change in the skill level of the operator in response to comparing the productivity of the machine with the productivity data;

providing an incentive to the operator for at least achieving a predetermined change in skill level, such predetermined change in skill level being  
10 determined by considering a normalized expected improvement in skill level, and the incentive being at least one of a reward, penalty, compensation, and failure to impose at least one of a reward, penalty and compensation;

15 determining whether the productivity of the machine is deteriorating and determining a productivity deterioration warning notice in response to performing subsequent comparisons of the productivity of the machine with the productivity data  
20 and considering the normalized expected improvement in skill level;

generating at least one message record including a signal indicative of the skill level; and

communicating the message record to at least  
25 one of the operator, a service organization, a customer and an owner of the machine.

30. A system for determining when a work machine needs service, comprising:

at least one machine sensor adapted to  
provide at least one machine sensor signal indicative  
of the operation performed by the machine, the payload  
handled by the machine and the amount of fuel consumed  
5 by the machine; and

a computer adapted to receive the sensor  
signals, calculate the productivity of the machine,  
determine a skill level of the operator, calculate the  
change in the productivity of the machine and skill  
10 level of the operator, determine whether the  
productivity of the machine is deteriorating and  
provide a service notice signal in response to the  
step of determining whether the productivity of the  
machine is deteriorating.

15  
31. The system of claim 30, wherein whether  
the productivity of the machine is deteriorating is  
determined as a function of at least one of the change  
in the productivity of the machine, the change in the  
20 skill level of the operator and the normalized  
expected improvement in skill level data.

32. The system of claim 30, wherein the  
computer is adapted to generate at least one message  
25 record, the message record including the service  
notice signal and including at least one communication  
device adapted to receive the message record and  
provide the message record to at least one of the  
operator, a service organization, the customer and an  
30 owner of the machine.

33. A system for determining when a work machine needs service, comprising:

at least one machine sensor adapted to  
5 provide at least one machine sensor signal indicative of the operation performed by the machine, the payload handled by the machine and the amount of fuel consumed by the machine; and

at least one data storage device adapted to  
10 store on a storage medium information including normalized operator productivity data for at least one work cycle and normalized expected improvement in skill level data;

a computer adapted to  
15 receive the sensor signals,  
calculate the productivity of the machine,  
determine a skill level of the operator, the skill level of the operator being  
20 determined by comparing the productivity of the machine with the normalized operator productivity data for the work cycle,

calculate the change in the productivity of the machine and skill level of  
25 the operator,

determine whether the productivity of the machine is deteriorating as a function of at least one of the change in the productivity of the machine, the change in the skill level of the

operator and the normalized expected improvement  
in skill level data,

provide a service notice signal in  
response to the step of determining whether the  
5 productivity of the machine is deteriorating,  
generate at least one message record,  
the message record including the  
service notice signal; and  
at least one communication device adapted to  
10 receive the message record and provide the message  
record to at least one of the operator, a service  
organization, the customer and an owner of the  
machine.

15 34. The system of claim 33, wherein the  
productivity is a function of an amount of fuel  
consumed and at least one of a payload handled by the  
machine and an operation performed by the machine.

20 35. A work machine adapted to be controlled  
by an operator and for acting upon a load through a  
plurality of work cycles, comprising:

a frame;  
a plurality of ground engaging devices  
25 supporting the frame;  
an operator compartment supported by the  
ground engaging devices;  
an implement having a linkage for operably  
connecting the implement to the frame;

an engine operably coupled to the ground  
engaging devices; and

a system for determining fees to be paid by  
a customer that are based on machine productivity,  
5 including:

at least one machine sensor adapted to  
provide at least one machine sensor signal indicative  
of the operation performed by the machine, the payload  
handled by the machine and the amount of fuel consumed  
10 by the machine; and

a computer adapted to receive the sensor  
signals, calculate the productivity of the machine,  
determine a skill level of an operator of the machine,  
the skill level of the operator being determined by  
15 comparing the productivity of the machine with the  
normalized operator productivity data for the work  
cycle, and select an agreement establishing a price in  
response to the skill level.

20 36. The work machine of claim 35, wherein  
the productivity is a function of an amount of fuel  
consumed and at least one of a payload handled by the  
machine and an operation performed by the machine.

25 37. The work machine of claim 35, wherein  
the agreement establishes at least one minimum  
productivity limit and corresponding price.

30 38. The work machine of claim 35, including  
at least one communication device adapted to receive



the price and provide the price to at least one of the operator, a service organization, the customer and an owner of the machine.

- 5                   39. A work machine adapted to be controlled  
by an operator and for acting upon a load through a  
plurality of work cycles, comprising:
- a frame;
  - a plurality of ground engaging devices
  - 10 supporting the frame;
  - an operator compartment supported by the  
ground engaging devices;
  - an implement having a linkage for operably  
connecting the implement to the frame;
  - 15 an engine operably coupled to the ground  
engaging devices; and
  - a system for determining when a work machine  
needs service, including:
    - at least one machine sensor adapted to
    - 20 provide at least one machine sensor signal indicative  
of the operation performed by the machine, the payload  
handled by the machine and the amount of fuel consumed  
by the machine; and
    - a computer adapted to receive the sensor
    - 25 signals, calculate the productivity of the machine,  
determine a skill level of the operator, calculate the  
change in the productivity of the machine and skill  
level of the operator, determine whether the  
productivity of the machine is deteriorating and
    - 30 provide a service notice signal in response to the

step of determining whether the productivity of the machine is deteriorating.

40. The work machine of claim 39, wherein  
5 whether the productivity of the machine is  
deteriorating is determined as a function of at least  
one of the change in the productivity of the machine,  
the change in the skill level of the operator and the  
normalized expected improvement in skill level data.

10

41. The work machine of claim 39, wherein  
the computer is adapted to generate at least one  
message record, the message record including the  
service notice signal and including at least one  
15 communication device adapted to receive the message  
record and provide the message record to at least one  
of the operator, a service organization, the customer  
and an owner of the machine.

20 42. A system for determining fees to be  
paid by a customer that are based on machine  
productivity, comprising:

at least one machine sensor adapted to  
provide at least one machine sensor signal indicative  
25 of the operation performed by the machine, the payload  
handled by the machine and the amount of fuel consumed  
by the machine; and

a computer adapted to receive the sensor  
signals, calculate the productivity of the machine,  
30 determine a skill level of an operator of the machine,

5

10

15

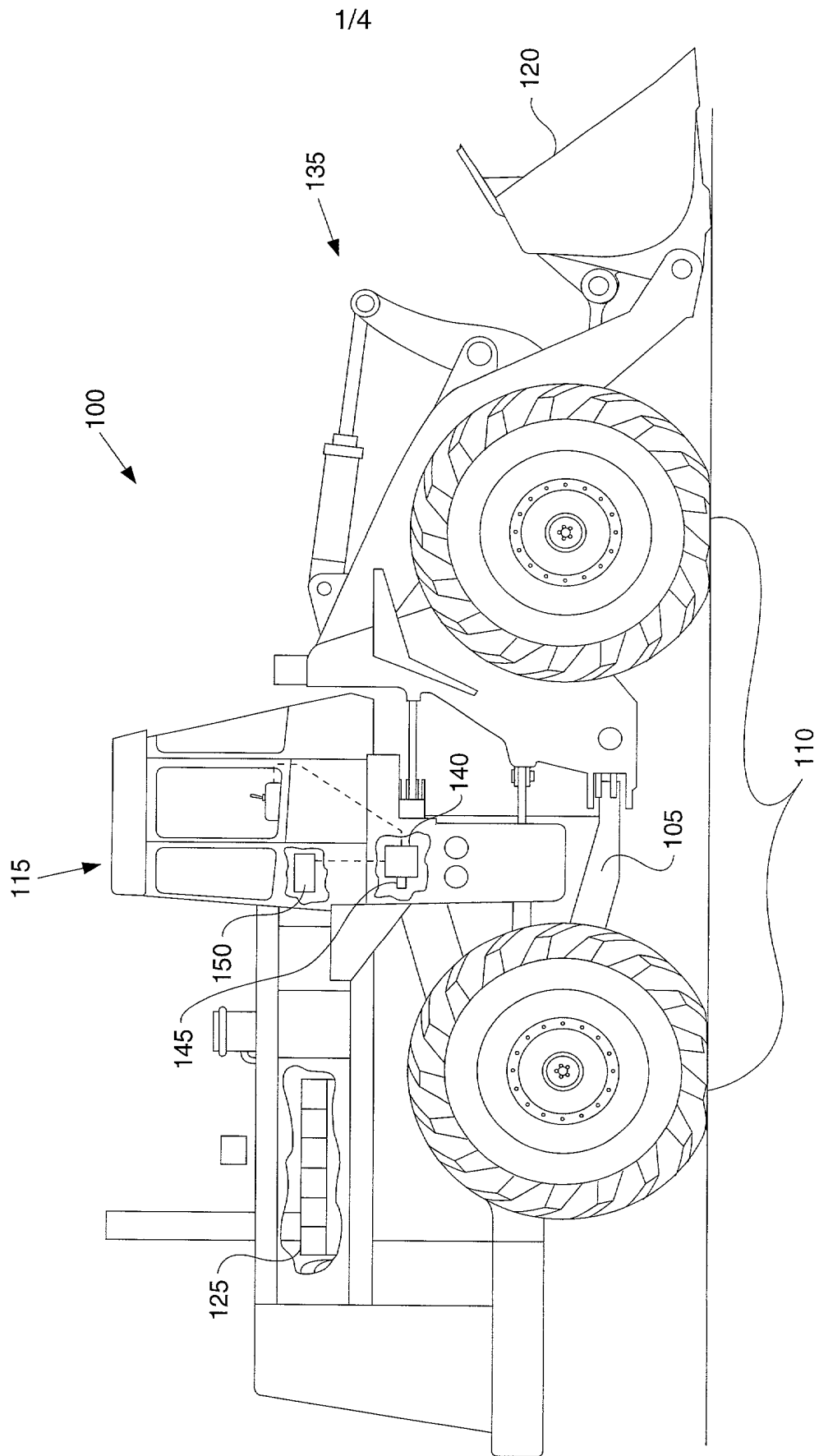
20

# APPARATUS AND METHOD OF PROVIDING A WORK MACHINE

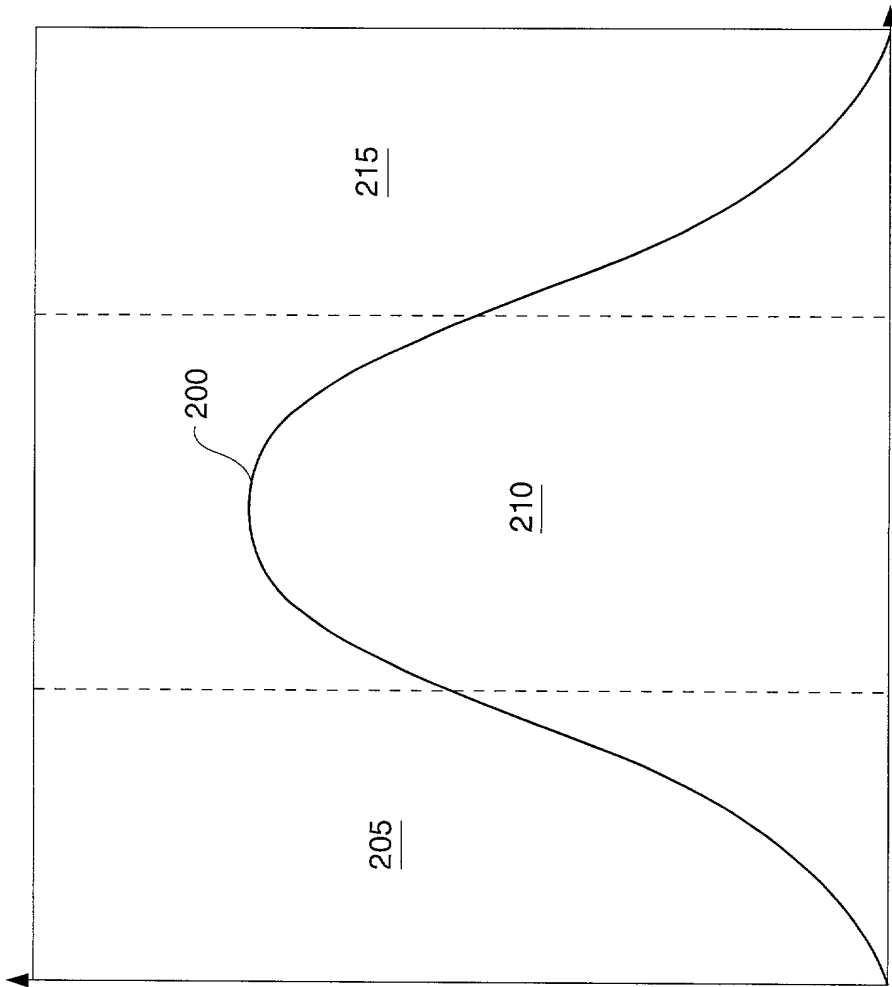
5           An apparatus and method of providing a work machine to a customer is disclosed. An embodiment includes at least one machine sensor and at least one computer. Signals indicative of the work performed by the machine are provided. The computer receives the  
10 signals and calculates the productivity of the machine.

# FIG. 1 -

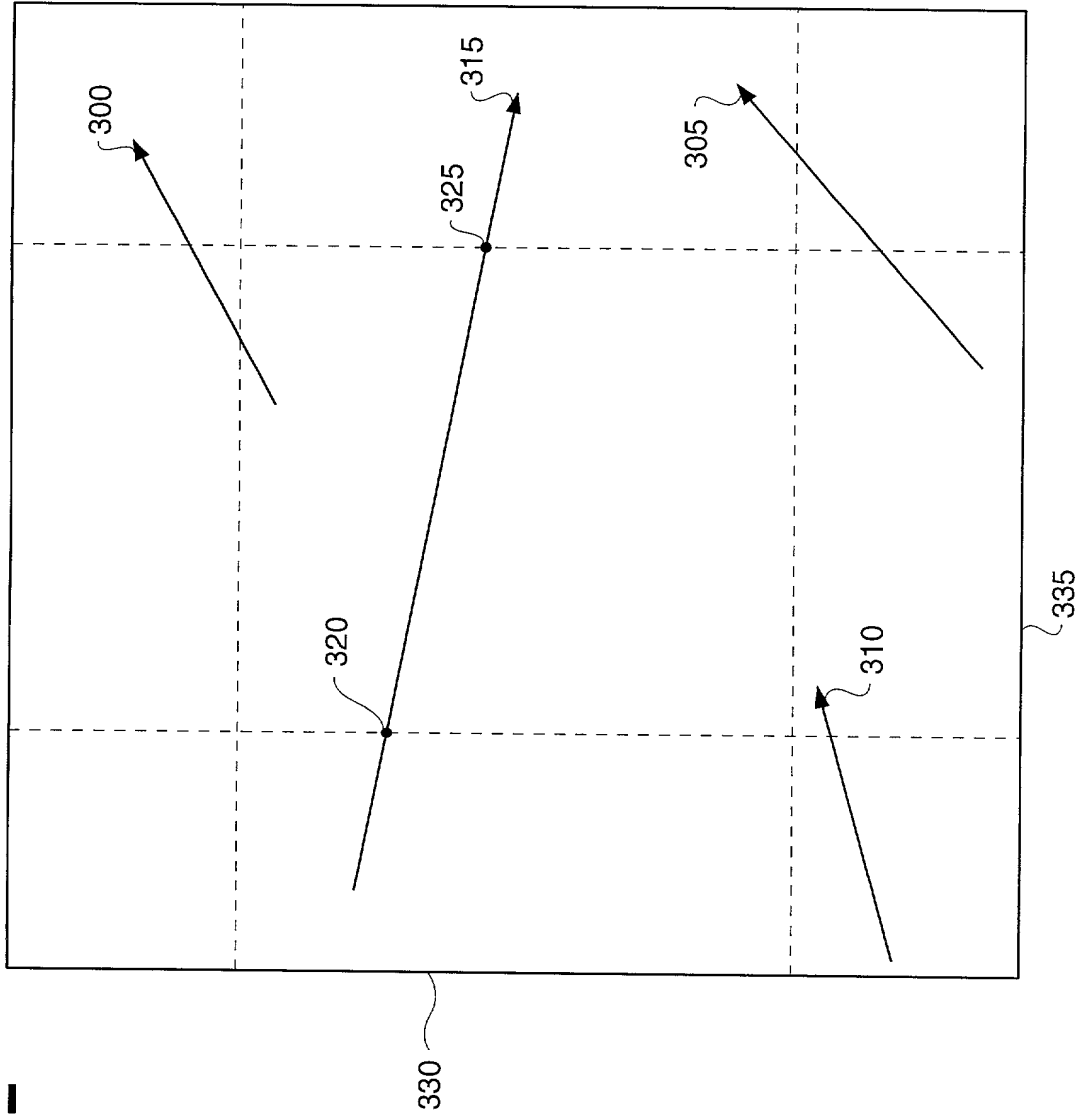
OFF SET 60



# Fig. 2 -

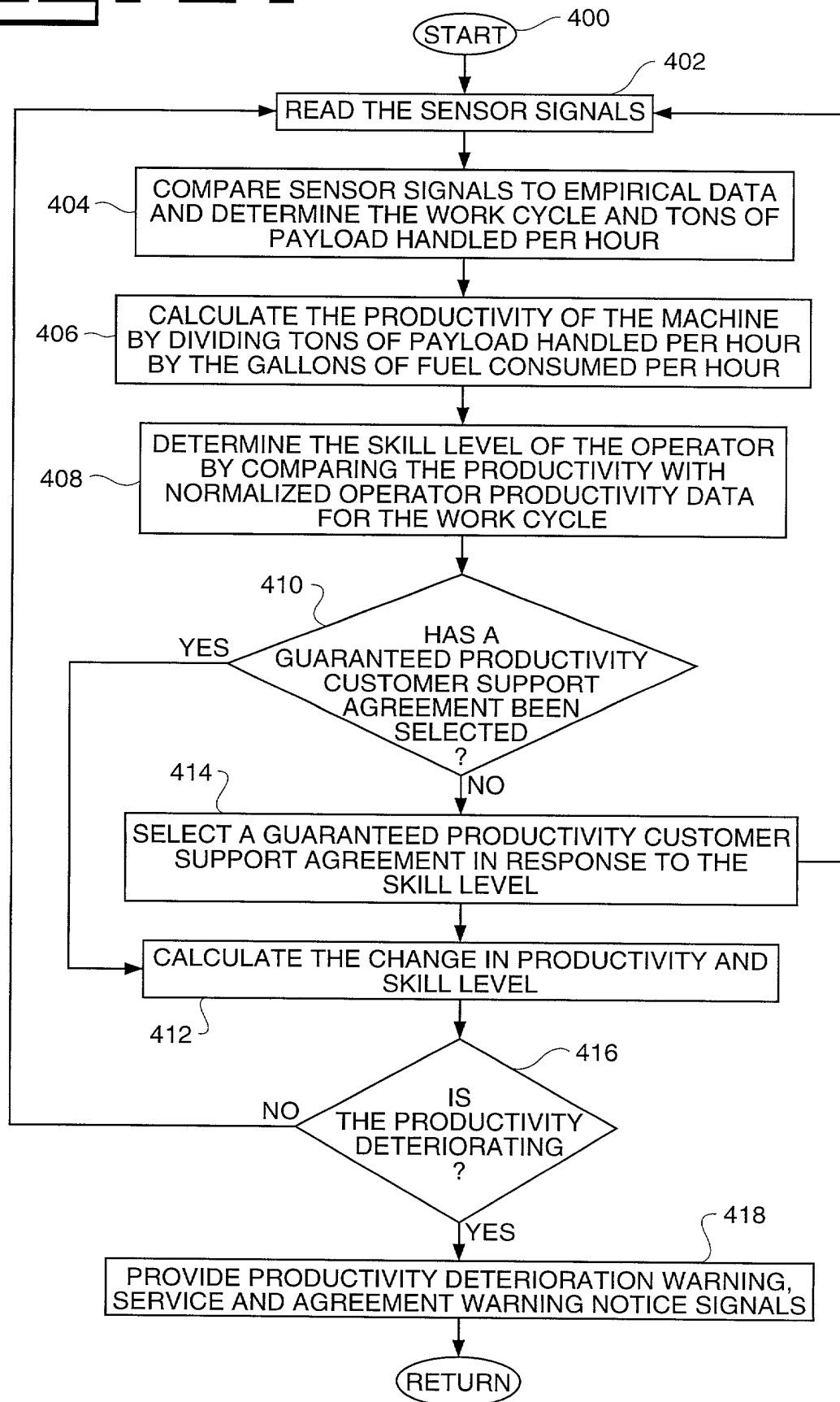


# FIG. 3



# FIG - 4 -

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[illegible]

## APPARATUS AND METHOD OF PROVIDING A WORK MACHINE

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims.

Provisional Application Serial Number: 60/210,058

I hereby appoint Byron G. Buck II, Patent Office Reg. No. 40,537, telephone (309) 675-6717, Joseph W. Keen, Patent Office Reg. No. 28,432, telephone (309) 675-5753, Robert J. Hampsch, Patent Office Reg. No. 36,155, telephone (309) 675-5214, and R. Carl Wilbur, Patent Office Reg. No. 36,056, telephone (309) 675-5847, my attorneys and/or agents, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected with this application. Please address all correspondence to: Byron G. Buck II, Caterpillar Inc., Intellectual Property Department, AB6490, 100 N.E. Adams Street, Peoria, Illinois 61629-6490.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

THOMAS P. MULLER Date 11/11/2000

Post Office Address:

26 Caymen Drive  
Montgomery, Illinois 60538